
Space Weather Technical Forecast

Issued on Monday, 27 November 2023 at 00:59 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Isolated M-class flares/R1-R2 Radio Blackouts likely throughout. Chance of G1 Geomagnetic Storms Days 1-2 (25-26 Nov).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with a peak C3.6 flare at 26/0744 UTC from AR3490 near the northern centre disc. There are eleven sunspot regions currently on the visible disc. Just west of centre disc in the northern hemisphere there is a cluster of three sunspot regions that appear to be contained within the same area of plage and connected magnetically. AR3492 (Hax/Alpha) is the largest group within the region and consists of two large unipolar spots, with opposite polarity trailing spots now faded. AR3502 (Dao/Beta) and AR3490 (Dao/Beta), to the south and north of AR3492 respectively, remain largely unchanged.

The largest sunspot group currently on the disc is AR3500 (Dkc/Beta-Gamma-Delta) in the southeast. This compact region primarily consists of a large delta spot and other mature spots in close proximity. AR3499 (Dai/Beta) in the southwest has seen some slight growth and has become more magnetically complex recently and is now classed as a Dkc/Beta-Gamma.

The other groups on the disc have remained largely stable and are generally smaller or simpler than those mentioned above.

No Earth-directed CMEs have been observed in the past 24hrs.

Solar Wind / Geomagnetic Activity: Solar wind speeds have been largely at elevated levels through the day but also on a gradual decline, initially around 550km/s but falling to around 500 km/s from around 2200 UTC. Solar wind density was average to above average varying between 9-14 pccc. The Interplanetary Magnetic Field (IMF), Bt has been weak and on a slow, steady decline, initially at 7.0nT, and ending around 4.5nT. The important north-south component, Bz was predominately positive, but has varied weakly between +5 nT and -6 nT. Phi angle has been almost consistently positive (away from the Sun). The resultant geomagnetic activity was initially at Active levels (Kp4), before dropping quickly to unsettled (Kp3), then to quiet levels (Kp0-2) from 0900 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux has been at Background levels throughout the period. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) on a gradually declining trend. The fluence observation at 27/0000 UTC was 1.55e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Moderate with isolated M-class flares (R1-R2, Minor-Moderate) likely and a slight chance of an isolated X-class (R3-Strong) flare. The main flare risk is from regions currently positioned on the eastern solar hemisphere and those in the cluster close to the centre of the disc in the north.

Solar Wind / Geomagnetic Activity: A CME is in the forecast and is associated with the 24/0933 UTC M1.1 flare from AR3499 in the southwest quadrant of the disc. This is expected to

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miss below Earth's orbit with just a slight chance of a glancing blow around 1200 UTC during Day 1 (27 Nov), however there is some uncertainty regarding this CME.

Solar wind speeds have been largely at elevated levels through the day but also on a gradual decline, initially around 550km/s but falling to around 500 km/s from around 2200 UTC. This is consistent with a connection with a HSS from CH75/+ which we are likely to have been connected to throughout the past 24 hours and may remain under its influence over Days 1-2 (27-28 Nov). Solar winds are therefore forecast to remain at, or close to, elevated levels at around 480-520 km/s through Day 1 and perhaps also into Day 2, before a steady decline back to ambient wind speeds. There does remain an element of uncertainty regarding the current positioning of the HSS, as well as any further CME enhancements over Days 1 as mentioned, which could see a temporary slight rise in solar winds speeds during Day 1.

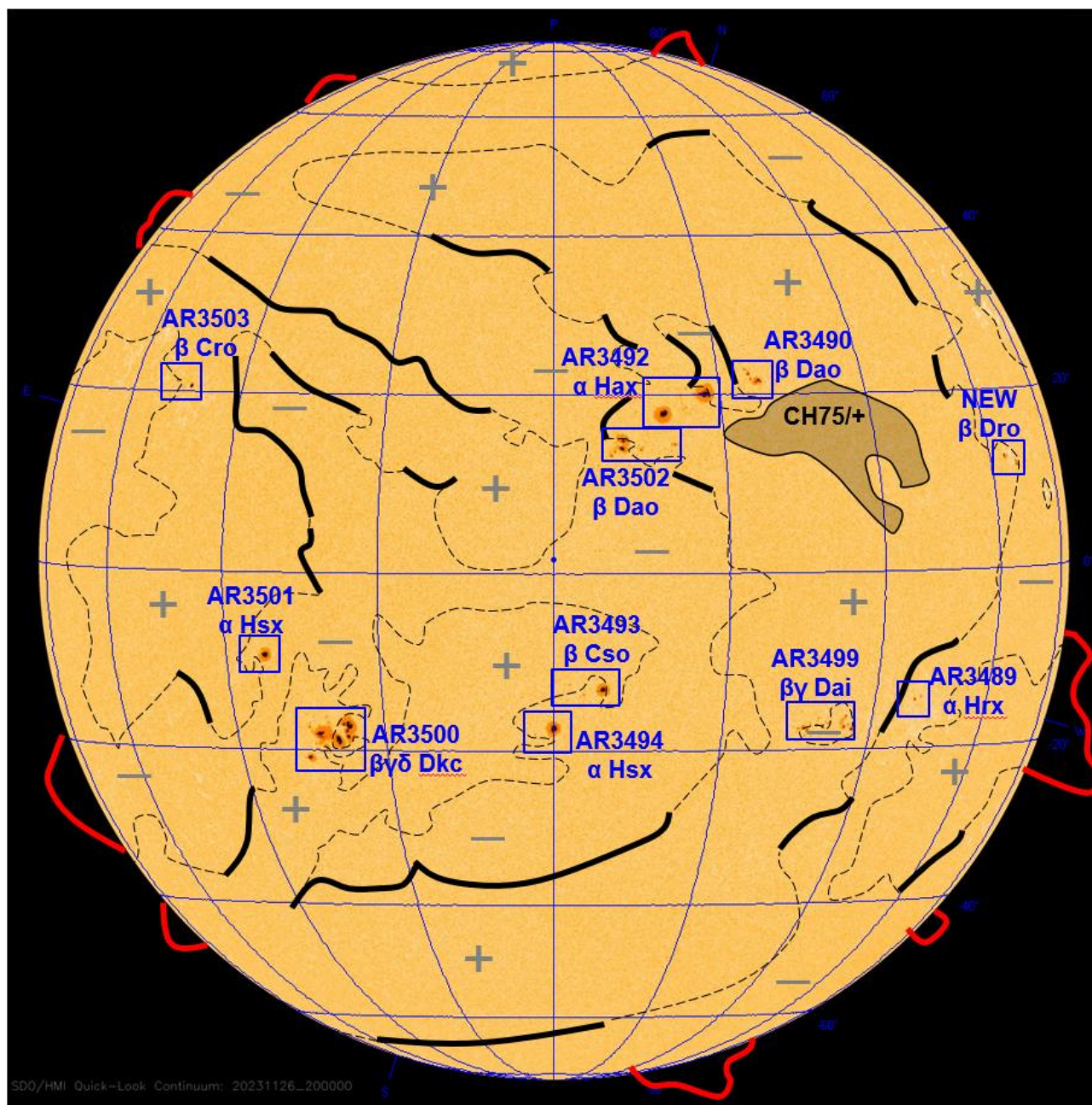
Geomagnetic activity is currently at Quiet levels (Kp0-2) and is expected to remain mostly at quiet/unsettled levels (Kp0-3) over the next few days. During day 1 there is a chance of some Active periods (Kp4) and a slight chance of seeing G1/Minor storm intervals due to the uncertainty of the glancing blow from the CME combined with HSS effects.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels. However there are several complex regions just west of the centre of the disc. These result in a slightly above background risk of an S1/Minor Solar Radiation Storm in the coming days.

Electron flux levels have been at Background levels due to the HSS connection. This suppression in electron flux is expected to persist through Day 1 (27 Nov). High levels of electron flux may be reached from Day 2, when there is an increasing chance that the reduction in the solar wind pressure from disconnection with the HSS could allow electron flux to subsequently increase.

Fluence levels are expected to remain below the 1e8 Active threshold at first. However as disconnection with the HSS becomes more likely throughout the period, the risk of a rise in fluence levels to slightly above the 1e8 Active threshold increases from Day 2.

Figure 1. Solar Analysis Valid 26/2000 UTC.



Key: Filament — , Prominence — , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

No Earth-directed CMEs have been observed leaving the Sun in the past 24hrs.

A CME is in the forecast and is associated with the 24/0933 UTC M1.1 flare from AR3499 in the southwest quadrant of the disc. This has been analysed and modelled as a likely miss below Earth's orbit with just a slight chance of a glancing blow around 1200 UTC during Day 1 (27 Nov). Multiple analyses of the coronagraph imagery from LASCO C3 and STEREO yielded a wide spread of possible timings and hence there is a high degree of uncertainty regarding possible CME arrival time, but impacts are expected to be negligible due to its expected trajectory.

Solar wind speeds have been largely at elevated levels through the day but also on a gradual decline, initially around 550km/s but falling to around 500 km/s from around 2200 UTC. This is consistent with a connection with a HSS from CH75/+ which we are likely to have been connected to throughout the past 24 hours. On the previous rotation, this coronal hole was a much larger and darker feature than it appears currently on imagery and resulted in speeds of 570km/s and a period of several days at elevated levels. The weaker state of the coronal hole and the approaching winter solstice fits with a slightly weaker connection, but we may remain under its influence over Days 1-2 (27-28 Nov). Solar winds are therefore forecast to remain at, or close to, elevated levels at around 480-520 km/s through Day 1 and perhaps also into Day 2, before a steady decline back to ambient wind speeds. There does remain an element of uncertainty regarding the current positioning of the HSS, as well as any further CME enhancements over Days 1 as mentioned, which could see a temporary slight rise in solar winds speeds during Day 1.

Geomagnetic activity is currently at Quiet levels (Kp0-2) and is expected to remain mostly at quiet/unsettled levels (Kp0-3) over the next few days. During day 1 there is a chance of some Active periods (Kp4) and a slight chance of seeing G1/Minor storm intervals due to the uncertainty of the glancing blow from the CME combined with HSS effects.

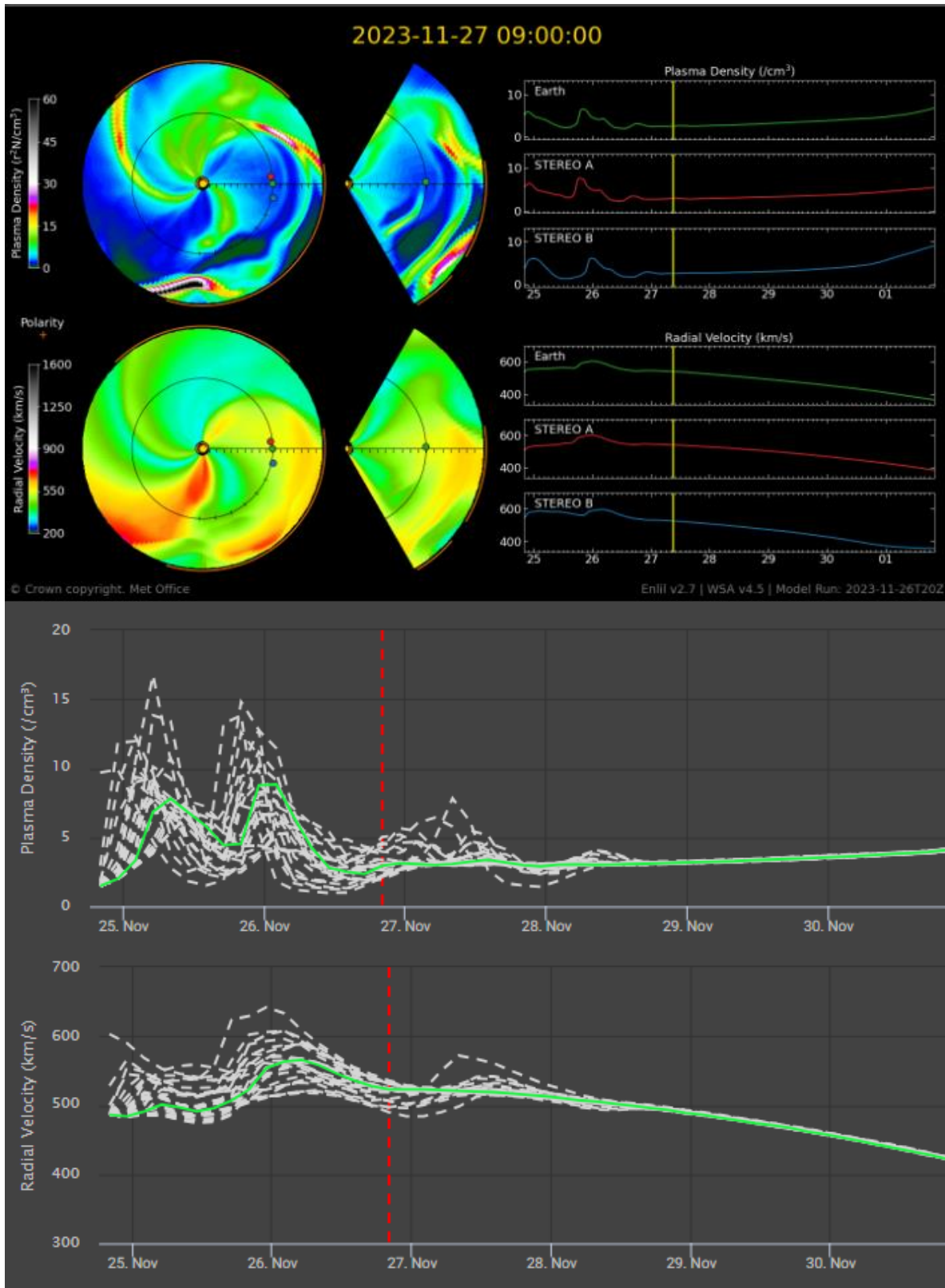
Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
24/1707	Partial	Filament Eruption	SE central disc	255 km/s		Slight chance of glancing blow



Figure 2: MOSWOC Enlil model and ensemble runs to show possible HSS and CME glancing blow.



Radio Blackouts - X-Ray Flares:

There are eleven sunspot regions currently on the visible disc. Just west of centre disc in the northern hemisphere there is a cluster of three sunspot regions that appear to be contained within the same area of plage and connected magnetically. AR3492 (Hax/Alpha) is the largest group within the region and consists of two large unipolar spots, with opposite polarity trailing spots now faded. AR3502 (Dao/Beta) and AR3490 (Dao/Beta), to the south and north of AR3492 respectively, remain largely unchanged.

The largest sunspot group currently on the disc is AR3500 (Dkc/Beta-Gamma-Delta) in the southeast. This compact region primarily consists of a large delta spot and other mature spots in close proximity. AR3499 (Dai/Beta) in the southwest has seen some slight growth and has become more magnetically complex recently and is now classed as a Dkc/Beta-Gamma.

One new unnumbered region has appeared recently in the far western hemisphere and appears to be growing in size and complexity, now classed as a Dro/Beta.

The other groups on the disc have remained largely stable and are generally smaller or simpler than those mentioned above.

Bright areas on SDO imagery and occasional CME activity just beyond the eastern limb suggests the presence of further active regions that are expected to rotate onto the visible disc by Day 3 (29 Nov). Hence Moderate solar activity is expected with isolated M-class flares, and a slight chance of an isolated X-class flare.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background levels.

There are several moderately-large and fairly complex regions just west of the centre of the disc in the northern hemisphere. These result in a slightly above background risk of an S1/Minor Solar Radiation Storm in the coming days. This risk remains small, but as these groups are in a more favourable location for connection with Earth there is a slight risk.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	15	15	15	15
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm ⁻² sr ⁻¹ s ⁻¹)						

High Energy Electrons Event ($\geq 2\text{MeV}$):

Electron flux levels have been at Background levels due to the HSS connection. This suppression in electron flux is expected to persist through Day 1 (27 Nov), given connection to the HSS (CH75/+) and possible glancing blow of a CME influencing the electron belt and geomagnetic activity. High levels of election flux may be reached from Day 2, when there is an increasing chance that the reduction in the solar wind pressure from disconnection with the HSS could allow the Van Allen belts to relax and electron flux at GEO to subsequently increase. However for this to occur on Day 2 this relies on possible glancing blow CME on Day 1 missing Earth.

Fluence levels are expected to remain below the $1\text{e}8$ Active threshold at first due to suppression of the electron belt. However as disconnection with the HSS becomes more likely throughout the period, the risk of a rise in fluence levels to slightly above the $1\text{e}8$ Active threshold increases from Day 2. The Met Office REFM is considered to be too quick to bring the rise in fluence in, but does show an increasing risk of higher fluence levels later in the period.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	5	20	30	30
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	5	10	20

Figure 5: MOSWOC REFM electron fluence

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